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TITLE: Discussion of Options for World Trade Center Sampling

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Following the panel meeting on April 12, and in subsequent emails from panel members, it has become clear that the panel would like to consider alternate options. The purpose of this document will be to outline key variables associated with sampling programs and then demonstrate how those variables play into example sampling plans that would meet different objectives. These example plans are not being offered as recommended plans – they are simply examples that provide the panel with some ideas that can further the discussions and help focus EPA's sampling efforts.

Three categories of key variables include: **contaminants/matrices sampled and sampling methods, sampling units, and design objectives.**

Variable 1. Contaminants/Matrices Sampled and Sampling Methods

The study design proposed by EPA staff called for the resampling of apartments for asbestos in air using the same air sampling protocol used in the original Region 2 sampling program. This design feature was driven by the objective defined in the CEQ letter of October, 2003: *"Post cleaning verification sampling to be done by EPA in the residential areas included in EPA's Indoor Air Cleanup to verify that re-contamination has not occurred from central heating and air conditioning systems"*. It was determined that "*post cleaning verification sampling"* to study for recontamination must be conducted using the same air sampling methods as were used in the original cleaning program. The panel has discussed moving away from this objective, most pointedly to include other contaminants, the matrix of dust in addition to (or in place of) the matrix of air, and as such, to include dust sampling methods such as wipes and/or

microvacs. The principal contaminants for consideration are the Region's Contaminants of Potential Concern, which include lead, dioxin, PAHs, fibrous glass, asbestos, and crystalline silica. The desire to sample for dust has been motivated by these considerations: 1) sampling for asbestos in air using a modified aggressive method might not be able to positively identify WTC asbestos or other dust-related contaminants, which might be present in dust that wouldn't be resuspended - that might exist embedded in carpets, furniture, or in places not impacted by the fans which resuspend the asbestos, 2) dust remains an exposure matrix, particularly for children, and 3) the "WTC signature" might be best ascertained by dust measurements rather than air measurements.

There has been discussion on the presence of a "WTC signature" that possibly could be identified in currently sampled dust. Presence of the WTC contaminants alone does not constitute a signature as most of these contaminants exist in lower Manhattan and other urban centers anyway. Perhaps the presence of a unique contaminant, a uniquely elevated concentration of a single contaminant, or a unique combination of contaminants, might constitute a valid signature. One example might be a high concentration of glass fibers in dust. This doesn't normally occur in urban dust, but it was identified following 9/11 in dust as a unique WTC-related contaminant in dust at elevated concentrations. Presence of this contaminant in dust near WTC today coupled with its absence in distant background locations might be evidence that this is a valid WTC marker. However, prior to initiating a study with the goal of finding evidence of a "WTC signature" in dust sampled in indoor settings in Lower Manhattan, research is required in order to verify that such a signature exists and validate an analytical method capable of measuring the signature. This research could be based on analysis of archived air sample filters. Differences in filters taken from apartments that were clearly contaminated could be compared with filters from the background sampling conducted by Region 2, for example.

With regard to dust sampling, use of wipes and microvacs has been discussed. The advantage of microvacs is that there are some standards available with which to compare results; the disadvantage to microvac sampling is that it breaks down asbestos and one could not ascertain the presence of larger versus smaller fibers. Wipe sampling does not break down asbestos fibers, but the disadvantage is that there are no health-based or other benchmarks available with which to compare results. A disadvantage to dust sampling of any kind is that health-based benchmarks are not common for contaminants in dust. EPA staff have emphasized that sampling for any contaminants should not occur until there are decision rules and evaluation criteria in place with which to interpret and act on results of the study. EPA staff believe that it is important to not only be able to define what constitutes "contamination", but what actions result from a finding of "contamination".

Variable 2. Sampling Units

Sampling units are a key consideration in planning a study. The original study only included apartments as the primary sampling unit because the objective was to assess recontamination within the clean-up area and apartment specific data on asbestos levels were available that could be used as the basis for assessing whether contamination had re-occurred. In panel discussions and emails, three other "sampling units" have been discussed: buildings, common areas within buildings, and HVAC units. Use of "building" as a sampling unit would

require clarification of specific sampling definitions and protocols. On one end of the spectrum, a comprehensive building sampling design might include all (or a large proportion of all) apartments, work spaces, common areas, HVACs, and other spaces (if any), and alternately, one could sample only a limited number of spaces within a building to characterize that building. A sampling of common areas in buildings might be one way to obtain samples in a large number of buildings in an unobtrusive manner: only a building owner's approval would be required and none of the occupant's daily patterns would be disturbed. Common areas include hallways, lobbies, and stairwells. There were a limited number of common areas sampled in the original Clean-Up Program, so a re-sampling of these areas (if they can be carefully re-identified in a re-sampling effort) might be informative, particularly with an objective to study "recontamination". Also, a large number of apartments in the original clean-up program were within buildings that had "partial central HVAC" units, meaning that common areas were serviced by a central HVAC, but that apartments themselves were not serviced by these central HVACs. They were serviced by individual heat pumps and had vents to the outside within kitchens and bathrooms. Therefore, a study whose objective is to determine the role of central HVACs in the recirculation of WTC contaminants might sufficiently focus only on HVACs and common areas in buildings with partial central HVACs, without the need to sample within the apartments of those buildings. Logical locations to sample within HVACs would include near the vents that lead into areas which are also being sampled for WTC contaminants. Concurrent occurrence of key WTC contaminants within the HVAC and then within the apartment or common space nearby, in conjunction with sampling further away from the vents, seems like a reasonable approach to study the role of HVACs in the recirculation of WTC contaminants.

One issue with buildings, common areas, and HVACs, as compared to apartments as the sampling unit, is the role of statistical design in the selection of sampling units. As a well-defined sampling unit, apartments that were previously sampled as part of the Region 2 Clean-Up were well suited to a statistical design: they are a distinct population from which to randomly select and sample. Even a newly designed study which randomly samples from all apartments within the clean-up zone (not only those which had been previously cleaned/tested) would have a statistical basis in the sampling unit selection process. There is less clarity for buildings, common areas within buildings, and within HVACs. As will be discussed below, EPA staff have categorized and catalogued all buildings in Lower Manhattan, and it is possible that a statistical survey design could be based on a random selection from this catalogue. The availability of resources and the scope of the sampling is a significant factor in the design of the study. If resources are limited it may make sense to use "best engineering judgement" to select buildings to sample rather that a probability based design. For example, air dispersion modeling and/or satellite photography can be immensely helpful in delineating areas and buildings that were most impacted by WTC dust. Sampling of a number of "potentially impacted buildings" ascertained in this way, compared to buildings less impacted as evaluated by these measures, might be a reasonable approach that involves engineering judgement and not random selection and would constitute an effective use of scarce resources. Maybe even within buildings, sampling on the side facing Ground Zero, in conjunction with sampling on the opposite side, might be informative. It is important to acknowledge that a study based on judgment selection of sampling units constitutes a case study and does not support extrapolation of the results to a larger population.

Variable 3. Overall Sampling Objectives

Following are possible objectives for a new sampling program in Lower Manhattan and surrounding areas. These are not offered as the universe of possible objectives, but they do represent our understanding of the breadth of ideas discussed during panel meetings and in a series of post-survey emails from panel members.

Objective 1: Conduct a survey on apartments previously sampled in the Region 2 Clean-up Program to determine whether recontamination has occurred from HVACs or other sources. This was the objective of the original design and was developed based on the mandate from the CEQ letter. A foundation for this design objective is an understanding of the word, "recontamination". In the original proposal, it was defined in terms of apartments as: contaminated apartments that were then cleaned, and then possibly could become contaminated once again. Using that definition, one is restricted in sampling to only those apartments which had been cleaned and whose status was known after cleaning because of the sampling done to test for cleanliness. Obviously, this definition had, therefore, implications regarding the sampling method and contaminant to sample for – asbestos air sampling. The original study design did not explicitly sample for contaminants within HVACs; rather, the role of HVACs was to be examined by looking at overall survey results in "apartments in buildings served by HVACs" as compared to results for "all apartments".

Objective 2: Conduct a survey of apartments in the Region 2 clean-up program area and elsewhere (Brooklyn, Chinatown) to determine the current contamination status with regard to World Trade Center contaminants. This objective is more wide open than the one above, mainly because it is determining "contamination" status and not "recontamination" status. It demands difficult decisions on contaminants to sample for, sampling methods, and geographic extent of sampling. If sampling for a "WTC signature" is to be included, , it will be necessary to conduct research to be able to define characteristics of a "WTC signature" in a sample. A design to meet this objective could be statistical in that apartments could be selected with a statistically valid random selection procedure, which would allow for results to be extrapolated to all apartments. It has been stated in panel meetings that such a survey could include apartments already sampled from the original clean-up and hence, meet some of the objectives developed originally. However, it is doubtful that the sample size of previously cleaned apartments within a full sample set of randomly selected apartments would be large enough to be able to have reasonable error bounds. For example, a random selection of 750 apartments from all apartments in the clean-up zone might only yield 100 to 200 apartments that were previously sampled (given that the original study sampled 4200 apartments where there are over 30,000 apartments in the clean-up zone). Finally, this objective as stated, would not address the role of HVACs in the contamination of buildings. Simple additions to a statistically-based survey of apartments, such as sampling within common areas and HVACs in buildings that house the randomly selected apartments, might be informative with regard to the impacts of HVACs.

Objective 3: Conduct a screening-level survey of buildings to ascertain their contamination status with regard to World Trade Center contaminants, and the role of HVACs in circulating WTC contaminants within these buildings. The characterization of this study as

a "screening" study has important implications. First, such a study would not involve comprehensive building sampling but rather only limited sampling in each of a small number of buildings for the purpose of gathering information to be used to plan a future sample of a larger number of buildings. Within each building, one could focus on a small number of apartments if the building is an apartment building, or alternately, sample only in easily accessible areas such as common spaces and within HVAC units. Second, screening could have implications regarding the type of samples taken, the number of contaminants measured in each sample, and the analytical methods employed. Often, when "screening" for a problem, the purpose is to conduct rapid sampling using simple methods to ascertain whether a measurement falls "above the line" or "below the line". Two principal benefits from this type of an approach include: 1) the capability to sample from different types of buildings – residential, commercial, fire houses, office buildings, and other building types, and 2) the ability to collect information from buildings at distant locations and perhaps get a reasonable "background" sample. If the number of buildings and samples are limited, this sort of study could be done in a relatively short amount of time at relatively low cost.

Objective 4: Conduct comprehensive studies on a small number of buildings to determine their current contamination status as well as the role of HVACs in circulating WTC contaminants. Such a study could prove costly and difficult to implement, requiring full building access to all apartments, common areas, and locations within the HVAC system. It has been suggested that a way to enlist participation in such a study would be to involve the building and apartment owners in focus group discussions up front. Again, up front work on decisions regarding what to sample for, where to sample, how to interpret and react to results, and so on, would be required for such a study. Of all study types, however, this one is probably best suited to fully evaluate the current status of buildings that may have been impacted by the collapse of the WTC towers, and also to most validly correlate HVAC measurements with measurements elsewhere in the building. If such a study was conducted in buildings that were fully cleaned and then sampled, such as some of the comprehensively cleaned buildings on Liberty Street, one might be able to address "recontamination" as well.

Before providing examples on how these four objectives can be met with different survey designs, four overarching issues should be addressed:

1) sampling for the presence of a "WTC signature" in dust or air – To date, there has been discussion of such a signature, but no specifics offered on what that signature entails. Before conducting any sampling to look for that signature, EPA staff recommends that research be undertaken to be able to elaborate on the specifics of that signature and to verify that it's existence in dust/air near 9/11 in time, if not also in currently sampled dust; The significance of such a "WTC signature" from an environmental perspective should also be addressed.

2) comparison of results from a new survey to some appropriate baseline - Since a study different from the one originally developed by EPA staff does not focus on comparing results with results previously obtained, it seems that comparison to something else, either (or both) a background concentration or newly developed health benchmarks, is needed;

3) post-survey data interpretation and rules for undertaking further activities - One needs to be

precise in laying out rules of data interpretation, with regard to delineating whether or not dust or air measurements supply evidence of WTC impact, with regard to health risk, and so on, before undertaking any study; and

4) decisions regarding recontamination versus contamination – It must be clear in any new sampling done by EPA what the objectives are with regard to "recontamination" and "contamination", and how the survey design will meet those objectives. The panel had discussed the notion that perhaps "recontamination" could be evaluated with a different study design than the one proposed by EPA. The original study design operated on the premise that the apartments were "cleaned" to below "contamination" levels, and now, the study will sample these same apartments to see if "contamination" had reoccurred. If contamination had reoccurred, a secondary objective was to determine if there was a relationship between current levels of contamination and the presence of HVACs. Any new study design purporting to be evaluating the potential for "recontamination" must be similarly rigorous in their definitions.

Following now are examples of four study designs that are based on these four objectives. These designs include other features that have been referred to, including contaminants to sample for and units of sampling.

EXAMPLE 1.

Objective: *Conduct a survey on apartments previously sampled in the Region 2 Clean-up Program to determine whether recontamination has occurred from HVACs or other sources.*

Approach: *As per the original proposed design, this design includes sampling in randomly selected apartments cleaned as part of EPA's Indoor Air Residential Assistance Program. Based on panel discussions, EPA staff would propose to make changes to the original design. One change is that apartments that were previously sampled aggressively would not be re-sampled. This results in a reduction in the universe size from 4167 to 3893. The two domains – all apartments and apartments with central or partial central HVAC –would be sampled with acceptable precision with a full sample of 500 apartments. Another change to the original design is the addition of microvac samples, which can be taken in HVAC units and also within the sampled apartments. The purpose of these newly proposed microvac samples would be to better correlate apartment results with possible causes for those results. In addition to asbestos in air, the microvac dust sampling could measure other contaminants as determined to be representative of WTC impacts. That may include lead, MMVF, or other contaminants.*

Air will be sampled for: TEM-PCMe, TEM-AHERA, TEM-(Non asbestos fibers), and PCM (Total fibers >5um). Samples taken during the original Clean-Up Program in 2002/3 were analyzed for these same contaminants so these results will be directly comparable to the earlier samples.

At the same time microvac samples can be taken in central HVAC duct work in buildings that have central HVAC in this retesting program, in casings of in-apartment heat pumps, and from at

least two horizontal surfaces within the areas where air sampling occurs. One surface would be a porous one such as a rug or a couch. The second would be a relatively inaccessible surface such as the top of a book case that is not cleaned regularly. These microvac samples could be analyzed for contaminants that will be decided upon in future discussions. Whereas these HVAC samples cannot be compared to any samples previously taken in the apartment Clean-Up Program, results can be extrapolated to the universe of apartments, and also they can be qualitatively compared to results from air sampling in the apartments. For example, one can determine whether the highest concentrations found in the apartment microvac (or central HVAC microvac) samples correspond to the highest air samples in the apartments.

While in the buildings, common areas can also be sampled and these sampling sites could correspond to sampling of HVAC vents. Therefore, sampling in apartments, HVACs, and common areas should provide useful information in addition to the air sampling for asbestos conducted in the apartments.

Further, and as indicated above, EPA staff would recommend a change from the original design to only retest apartments previously sampled by modified aggressive sampling. Of the 4167 apartments tested in the Clean-Up program, 274 were tested using aggressive sampling, with the remaining 3893 apartments tested using modified aggressive sampling. Sampling in apartments where aggressive sampling was performed, and sampling them aggressively once again, presents both logistical and results interpretation problems, and for these reasons, EPA staff recommends they be excluded from any study design that includes retesting of apartments previously tested in the apartment Clean-Up Program.

Finally, and again referring to the original design, EPA staff recommends limiting the number of apartments sampled to 500. This sample size will allow EPA to estimate the current contamination rate with acceptable precision while conserving resources to allow EPA to conduct other studies, if desired.

EXAMPLE 2.

Objective: *Conduct a survey of apartments in the Region 2 clean-up program area and elsewhere (Brooklyn, Chinatown) to determine the current contamination status with regard to World Trade Center contaminants.*

Approach: *Randomly selecting according to a statistical design from among all apartments in the Clean-Up Zone and elsewhere, such as Brooklyn and Chinatown, will allow for extrapolation to all apartments in these areas. There would need to be a fair amount of work up front to hammer out the details of such a design. Specifically, it is unclear how to meaningfully stratify a universe of all apartments – recall that stratification in the original survey design was based on characteristics of the originally sampled universe of apartments: modified aggressive versus aggressive sampling, clean & test versus test only, and results (ND, below or at benchmark, above benchmark). A stratified random sampling with oversampling of strata of most concern would be a desired goal for a new study. A "strata of concern" might be, for example, all apartments within 1 mile of Ground Zero. It is also unclear how to describe the precision*

associated with different sample sizes. Recall that precision for the original survey was described in terms of a rate of contamination, where "contamination" was defined as occurrence of asbestos in air above a benchmark, and there were prior results upon which to base guesses on the current rate of contamination. Similar prior knowledge is absent for a new study design. The major benefit from this type of study is that it provides an unbiased estimate of the current rates of occurrence/contamination of WTC contaminants in apartments that are near Ground Zero, and elsewhere of concern (Brooklyn/Chinatown). This could not be said of the original study; the study population had an inherent bias in that the apartments were originally self-selected to be part of the clean-up program. Another possible benefit is that information on how apartments were cleaned can be correlated to findings in the apartment.

Much of the detail as described above for a variation on the original study would apply here: the same contaminants and sampling methods would be employed, HVACs and common areas would be sampled in addition to the apartments within the buildings, and so on. Such a study could not evaluate "recontamination", at least as defined for purposes of the original study, but it would provide a meaningful baseline of current "contamination". Further, by determining how all sampled apartments were originally cleaned following 9/11, it may be possible to correlate rigor of cleaning to measurements. The panel has expressed a desire to also evaluate the effect of the cleaning method on current rates of occurrence/contamination.

Based on satellite imaging, plume dispersion modeling, and other data from 9/11, the most heavily impacted area in terms of the movement and settling of WTC dust are areas adjacent to Ground Zero with perhaps an emphasis on areas east and southeast of the WTC. Modeling, monitoring and remote sensing data should be used to develop a thesis about the extent of contamination that could be tested by execution of the study design. See figure 2 for an example of modeling for 10am on 9/11.

EXAMPLE 3.

Objective: *Conduct a screening-level survey of buildings to ascertain their contamination status with regard to World Trade Center contaminants, and the role of HVACs in circulating WTC contaminants within these buildings.*

Approach: *The proposal to meet this objective includes sampling common areas and central HVACs in a fairly large number of buildings, on the order of 30 – 50 buildings, selected on the basis of judgment to provide a cross section of lower Manhattan building types. Samples would include air samples in the common areas and microvac samples in the common area and in the central HVACs, and contaminants analyzed could include asbestos and possibly other contaminants that can be identified as "signature" contaminants for WTC dust.*

The concern has been expressed that inhabitants continue to be exposed to WTC related contaminants in the home and in the workplace. In order to evaluate this possibility, a large-scale screening level survey of buildings most likely to be impacted by the collapse of the WTC towers may be appropriate. To maximize the rate of participation as well as the number of buildings surveyed, it is recommended that samples be selected in building locations that are

most easily accessible with a minimum of disturbance to individuals living or working in the buildings. Specifically, a large-scale screening-level survey of buildings might work best if sampling were limited to common areas and within central HVAC units. Such a strategy would obviate the need to enlist participation of apartment owners, and can be conducted with a minimum amount of disruption in the buildings. A wide cross-section of building types can be targeted, as described below. Buildings in distant locations, such as in Brooklyn or Chinatown, can be part of this effort. Finally, we will use the results from previous background sampling as comparisons to this current effort.

There are about 800 parcels of land in the area most heavily impacted. Some of the parcels are vacant or are used for purposes not likely to result in long term exposure to the public. Examples of parcels where exposure is not likely to occur includes outdoor areas such as parking lots, cemeteries, etc. A screening-level survey of buildings would be more expedient if these parcels were excluded from the sampling program. For purposes of this example, the remainder were divided into 10 building classes. These classes are: commercial, houses of worship, residential, mixed use, government buildings, schools & hospitals, hotels, offices, unknown, utility, and outdoor spaces.

Based on satellite imaging, plume dispersion modeling, and other data from 9/11, the most heavily impacted area in terms of the movement and settling of WTC dust are areas adjacent to Ground Zero with perhaps an emphasis on areas east and southeast of the WTC. Figure 1 shows census tracts around Ground Zero, and based on this finding, the tracts most likely to be impacted include 1300, 1501, 1502, 2100, 31701, 700, and 900. Table 1 shows the number of buildings, by class, in all 17 census blocks shown in Table 1. There are a total of 2233 buildings in these 17 blocks. It is proposed that at least one building from each class be sampled, and then buildings can be added based on the size of the class: the largest class of "commercial" can have as many as 10 buildings sampled. Based on resources available, and numbers of samples per building, such a survey would entail probably from 30 to 50 buildings. It is suggested that buildings be selected using best engineering judgment rather than by a random procedure. Some of the selection criteria that could be used includes: 1) proximity to Ground Zero, 2) knowledge or evidence of prior contamination, 3) most potential for exposure based on largest number of individuals living or working in the building which might lead to selection of buildings with the most floors, 4) alternately, largest potential average individual exposure which might lead to selection of buildings with the smallest number of floors, or some other criteria.

Within each building, and similar to other designs above, central HVAC unit can be sampled with a microvac (if there is a central HVAC unit), and one or more common areas can be sampled. The common area sampling could include air sampling as well as microvac sampling. Microvac samples can be taken in central HVAC duct work leading to air sampled areas, and also from a horizontal surface within the areas where air sampling occurs. Air samples could be measured for TEM-PCMe, TEM- AHERA, TEM-(Non asbestos fibers), and PCM (Total fibers >5um). Dust samples can also be measured for asbestos and other contaminants that might be associated with a WTC signature. At least two buildings each can be sampled in the most heavily impacted areas in Brooklyn and in less heavily impacted areas near the Manhattan Bridge. According to plume modeling and satellite imaging, the wind direction on 9/11 itself was south/southeast. Figure 2 shows results of a plume modeling exercise demonstrating this

trend.

Results from this sampling can be compared to data collected in previous sampling of background apartments. The comparison would allow EPA to determine how indoor concentrations in the buildings in Brooklyn most likely impacted and areas near the Manhattan Bridge most likely not significantly impacted by dust from the collapse of the towers compare to lower Manhattan values and to background values.

It is important to note that information collected in this type of study cannot be easily or immediately tied to a potential exposure or health effect since the sampling is not being conducted directly within an apartment or a working space. The intent, as indicated in the objective, is to identify the presence and levels of WTC contaminants in a large number of buildings and also to study the role of HVACs in these buildings. Still, there would need to be an action plan for follow-up activities if high levels of contaminants are found.

EXAMPLE 4.

Objective: *Conduct comprehensive studies on a small number of buildings selected carefully on the basis of judgment to determine their current contamination status as well as the role of HVACs in circulating WTC contaminants.*

Approach: *This proposed study design includes a careful selection of a small number of buildings and, to the extent possible, the goal of sampling all apartments in the buildings, numerous common area locations, and locations within the HVAC units. Sampling methods would include air sampling for asbestos, and dust sampling for asbestos and other contaminants that may indicate the presence of WTC impacts.*

All three of the previous study designs have sought to sacrifice building-specific study for the purposes of gaining information on broader geographic areas and a larger number of locations. Realistically, the ability of the above studies to link HVACs to recontamination is likely to be limited. At best, one can hope for useful estimates of concentrations of WTC contaminants in dust in both HVACs and adjoining common space areas, or estimates of levels of asbestos in apartment air in buildings with HVACs as compared to estimates of levels in non HVAC building apartments. More definitive information about the role of HVACs in recirculating WTC contaminants possibly could be obtained by comprehensively studying a few key selected buildings.

One disadvantage to this study design is obviously the logistics of obtaining permission to conduct that much sampling within single buildings. Also, the ability to extrapolate beyond the immediate geographic area and similar building types is limited. If the buildings are not carefully selected, a large amount of resources could be spent studying a building that may only have been marginally impacted by the collapse of the WTC towers. Building selection thus becomes a critical component for the success of this type of study. The advantage to this type of study, given a good selection of buildings (and the definition of what a "good" building is, will be addressed shortly), one can make clear statements about the ongoing impacts from WTC

contamination within these buildings, and it may be reasonable to comment on similar ongoing impacts at very similar buildings near the sampled building. Also, with so much contained, concurrent HVAC sampling and sampling at locations near the HVAC and within apartments, this is the best possible study design to ascertain whether there is a relationship between measurements in and near HVAC vents.

In addition to sampling, information on prior cleaning efforts for common areas, HVACs, and apartments can additionally shed light on any relationships between measurements and cleaning practices. As noted earlier, this was a concern of panelists.

Some characteristics that are critical for building selection in this type of case study include: 1) evidence and preferably sampling results that prove that the building was impacted by the collapse of the WTC towers, 2) complete information on the cleaning that has been conducted on the building to date, and 3) buildings with central HVACs that preferably serve both the apartments and common areas.

Some candidate buildings for study include:

45 Wall St. – 430 apartments in this building were sampled in the original Region 2 Clean-Up Program and this building was one of the few buildings in that program where it was ascertained that apartments, in addition to common areas, were served by a central HVAC.

110 Liberty – This was the building of the Region 2 Confirmation Cleaning Study. Before and after sampling of all the COPCs, and dust sampling, is available for comparison with a current day sampling.

Any of the buildings that were determined to be have external contamination by NYCDEP survey teams.

Figure 1. Identification of census blocks in Lower Manhattan.

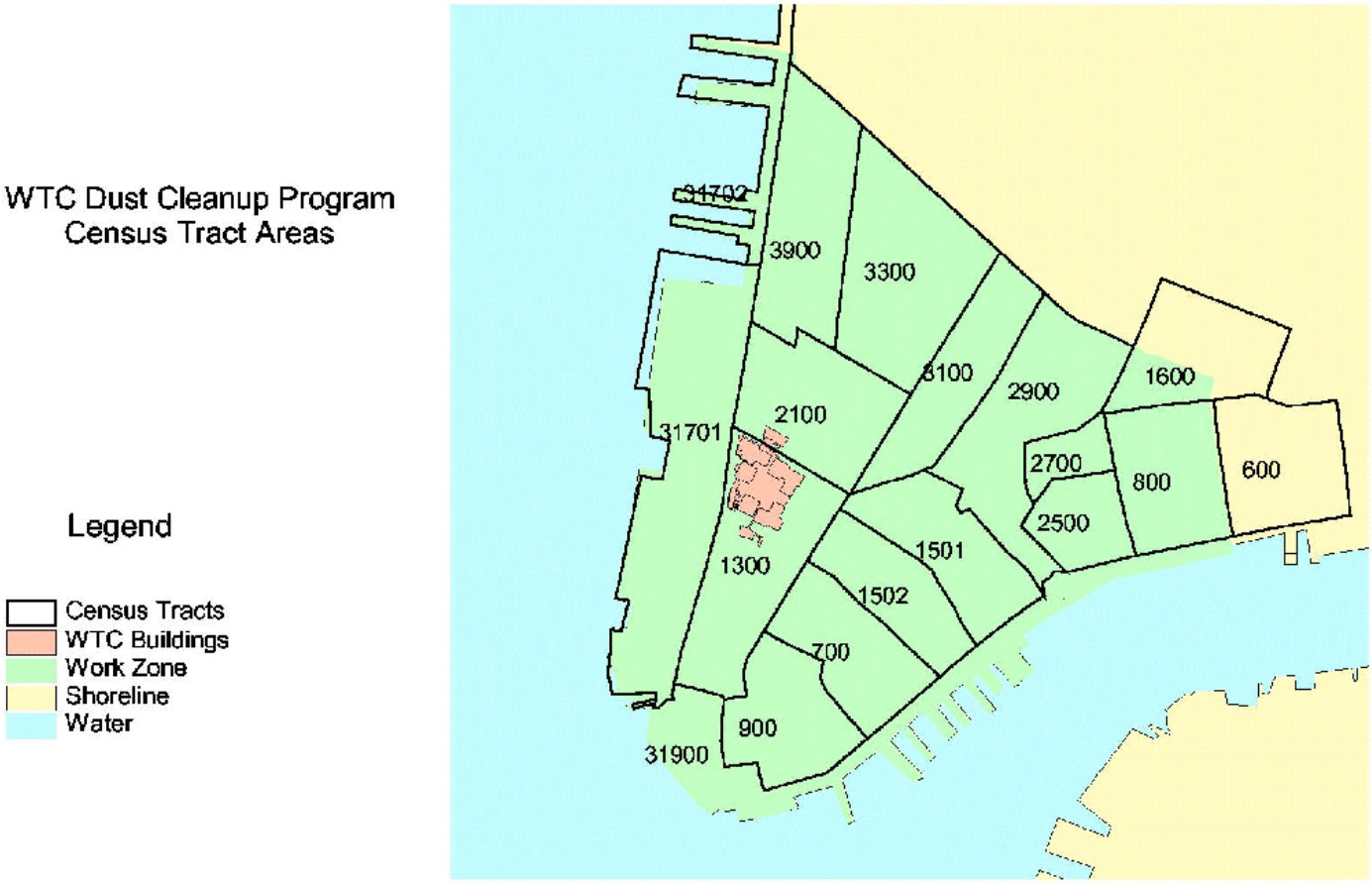

Table 1. Full catalogue of buildings in each census block in lower Manhattan (this table contains information for first 8 census blocks; next table includes remaining 8 census blocks and grand total).

Class	Class Description	DOF_BLDG_CLAS_DESC	1300	1501	1502	1600	2100	2500	2700	2900	3100
1	Commercial	Bank Bldg Exclusively for Bank			1		1		1	2	
1		Department Stores, Multi-Story	4		2					1	
1		Diners, Franchsed Type Stand alone			1						
1		Factory/Industry Miscellaneous				1					1
1		Factory/Industry/Spec. Construction									1
1		Funeral Home							2	2	
1		Garage - Two or More Stories	2	2	1						
1		Garage with Showroom									
1		Garage/One Story		1		1					
1		Gas Sta w/Enc Lube Plant/Wkshop									
1		Gas Sta wo/Enc Lube Plant/Wkshop			1						
1		Loft Bldgs/Miscellaneous		12	1		7			7	16
1		Loft Bldgs/over 8 Stories	1		1	1					
1		Loft Bldgs/Semi-Fireproof									1
1		Loft Bldgs/with Retail Stores	1	29	1	7	50		2		8
1		Lofts/Fireproof & Storage Type			1						3
1		One or Two Car Garage									
1		One Story Store Building		1	3	1	2			1	2
1		Store Bldgs/Miscellaneous	7	18	39	3	7		8	30	8
1		Two Story or Store and Office	8	5	3	1	5			6	
1		Warehouses/Fireproof									
1		Warehouses/Miscellaneous		2		3					1
1		Warehouses/Semi-Fireproof									
2	Worship	Church, Synagogue, Chapel	2	1	1	2	2		3	5	1
2		Churches Synagogues/Misc.							1	1	
2		Mission House (Non-Residental)							2		1
2		Paronage, Rectory								1	
3	Residential	Condominiums	5	9	12	2	28		1	5	5
3		Condos/Apt Building W/Elev									
3		Condos/Apt/N.A.					1				
3		Condos/Commercial Bldgs									
3		Condos/One Family(Attached)		1							
3		Converted Dwelling/Rooming House					1				
3		Co-Op Convert from Loft/Wareho									
3		Elev Apts/Fireproof(w/Stores)			1		1	10			
3		Elev Apts/Semi-Frprof W/0 Store			2		3				
3		Elev Apts/Semi-Frprof w/Stores		2	2						
3		Elevator Apartments	1	2			2				1
3		Elevator Apt/Co-ops(no Condos)		11	2		6			2	
3		Elevator Apts Miscellaneous		1			2			2	
3		Elevator Apts/Converted		1	2						1
3		Elevator Apts/Luxury Type									

3		Multi Use 2 Fam w/Store or Ofc		1				1	2		
3		Multi Use/1 Fam w/Store or Ofc						1			
3		One Fam House/City Residence									
3		One Family/Miscellaneous		1							
3		Over Six Families w/o Stores						1			
3		Prime 3 Fam w/Store, Office		1	1	1		3	2		
3		Prime 4 Fam w/Store, Office		2	1	2	8	1	2		
3		Prime 5-6 Fam w/Store, Office	1	1			2		3		
3		Prime Fam/N.A.	1	1	1	2	7		15		
3		Two Family/Brick						1			
3		Two Family/Miscellaneous									
3		Walk-Up Apt/Cooperatives					4				
3		Walk-Up Apts/3 to 6 Families		1					1		
3		Walk-Up Apts/Old Law Tenements						6	28		
3		Walk-Up Apts/Over 6 Families						4			
3		Walk-Up Apts/Three Families									
3		Walk-Up Over 6 Fam w/Stores	3	1		23	1	6	90	1	
4	Mixed Use	Office Bldg/with Res Apts									
4		Stores/With Apartments Above	2	1					1		
5	Government	Court House							4	1	
5		Gov't Instal/Military and Naval									
5		Gov't Instal/Prisons, Jails, etc							2		
5		Gov't Installation/Dept of Sanitation									
5		Gov't Installations/Fire Dept	1	1							
5		Gov't Installations/Police Dept							1		
5		Library									
5		Museum									
5		Post Office								1	
6	Schools & Hospitals	Asylums and Homes/Misc						1			
6		City University									
6		Community Center							1	1	
6		Education Structures/Misc					1				
6		Hosp, Sanitariums, Mental Inst.		1							
6		Hospitals & Hlth/Staff Facilities		1							
6		Other Colleges and Universities	1	1			1				
6		Parachial Schools, Yeshivas	1					1	1		
6		Public Elementary Jr & Sr HS				1	1	1	2		
6		Recreation Facilities/Misc						1			
7	Hotels	Hotel/Lux Type Built After 1960	2		1						
7		Hotels/Apartments Hotels			1						
7		Hotels/Dormitories		1							
7		Hotels/Miscellaneous		2			1				
7		Hotels/Private Club, Lux Type	1				1				
8	Offices	Office 10 Fls & Over/Main Av	22	7	24		6		1	6	
8		Office Big/10 Fls & Over/Side St	1	1	3		4	1	1		

	8		Office Big/Fireproof to 9 Stores	2	4	16		4		1	
	8		Office Bldg/Semi-Fireproof		1	3		1			2
	8		Office Bldg/Tower Type	4	1	4		7		1	2
	8		Office Bldgs/Misc.	9	4	11		6		13	11
	8		Professioal Office Building					2	1		
	9	Unknown	(blank)	1	2			5		1	1
	9		Misc, Incl, Riding, Acadm & Stable	1						1	
	9		Miscellaneous				1				
	9		Other	1	5	1					
	10	Utility	Dept of Gas, Water, & Elec								
	10		Dept of Marine & Aviation		1						
	10		Dept of Public Works								
	10		Electric Utilities								
	10		Telephone Utilities							1	
	10		Transportation Facilities/Misc.	1							
	10		Transportation, Public Ownersh		1			1		1	
x		Outdoor Space	Bridges, Tunnels, Highways		1			1			
x			Cemeteries	1					1		
x			Licensed Parking Lot	2	2	1					
x			Parks	1						2	2
x			Playgrounds						1		1
x			Stadium, Race Track, Baseball Fl								
x			Vacant Land		8	5	1	3		4	4
x			Vacant Land/Fire Dept								
x			Vacant Land/Misc.		1	5			1	2	
x			Vacant Land/School Site or Yar								

Table 1a. Full catalogue of buildings in each census block in lower Manhattan (this table contains information for the second 8 census blocks and the grand total).

Class	Class Description	DOF_BLDG_CLAS_DESC	31701	3300	3900	500	600	700	800	900	Grand Total
1	Commercial	Bank Bldg Exclusively for Bank		2							7
1		Department Stores, Multi-Story									7
1		Diners, Franchsed Type Stand alone									1
1		Factory/Industry Miscellaneous		1	4				1		8
1		Factory/Industry/Spec. Construction			1				1		3
1		Funeral Home									4
1		Garage - Two or More Stories			4					1	10
1		Garage with Showroom		1							1
1		Garage/One Story		3	1		1		2		9
1		Gas Sta w/Enc Lube Plant/Wkshop			1				1		2
1		Gas Sta wo/Enc Lube Plant/Wkshop		1	1						3
1		Loft Bldgs/Miscellaneous		88	23				2	3	159
1		Loft Bldgs/over 8 Stories		1	1		1				6
1		Loft Bldgs/Semi-Fireproof		1							2
1		Loft Bldgs/with Retail Stores		22	6		2	1	32		161
1		Lofts/Fireproof & Storage Type		1						1	6
1		One or Two Car Garage							11		11
1		One Story Store Building		8			3		1		22
1		Store Bldgs/Miscellaneous		10	4		2	4	20	24	184
1		Two Story or Store and Office		14	2		2	1	2	1	50
1		Warehouses/Fireproof			5						5
1		Warehouses/Miscellaneous		8	28		1				43
1		Warehouses/Semi-Fireproof			2						2
										1 Total	706
2	Worship	Church, Synagogue, Chapel		1			4	1	7	1	31
2		Churches Synagogues/Misc.					3		2		7
2		Mission House (Non-Residental)					2				5
2		Paronage, Rectory									1
										2 Total	44
3	Residential	Condominiums	11	51	36		2	6	6	5	184
3		Condos/Apt Building W/Elev		1							1
3		Condos/Apt/N.A.									1
3		Condos/Commercial Bldgs		1	2						3
3		Condos/One Family(Attached)									1
3		Converted Dwelling/Rooming House		2	1						4
3		Co-Op Convert from Loft/Wareho		1							1
3		Elev Apts/Fireproof(w/Stores)	6	1	10		5		12		46
3		Elev Apts/Semi-Frprof W/0 Store		6	4		1				16
3		Elev Apts/Semi-Frprof w/Stores					2				6
3		Elevator Apartments		9	16					1	32
3		Elevator Apt/Co-ops(no Condos)		14	13						48
3		Elevator Apts Miscellaneous			1		2	1	1	1	11
3		Elevator Apts/Converted		3	4				1		12
3		Elevator Apts/Luxury Type	6								6

3		Multi Use 2 Fam w/Store or Ofc		4	4	1	3		16
3		Multi Use/1 Fam w/Store or Ofc		4	5				10
3		One Fam House/City Residence		1	1				2
3		One Family/Miscellaneous		1	11	1			14
3		Over Six Families w/o Stores			1	1	4		7
3		Prime 3 Fam w/Store, Office		7	5	1	4	1	26
3		Prime 4 Fam w/Store, Office		12	8	4	1		41
3		Prime 5-6 Fam w/Store, Office		3	3		4		17
3		Prime Fam/N.A.		11	4	4	4	3	53
3		Two Family/Brick							1
3		Two Family/Miscellaneous			7				7
3		Walk-Up Apt/Cooperatives		4	2				10
3		Walk-Up Apts/3 to 6 Families			1		1		4
3		Walk-Up Apts/Old Law Tenements		2	2	8	22		68
3		Walk-Up Apts/Over 6 Families				2	1		7
3		Walk-Up Apts/Three Families			1	1			2
3		Walk-Up Over 6 Fam w/Stores		9	6	27	83		250
								3 Total	907
4	Mixed Use	Office Bldg/with Res Apts		2			1		3
4		Stores/With Apartments Above		1			1	1	7
								4 Total	10
5	Government	Court House						1	6
5		Gov't Instal/Military and Naval				1			1
5		Gov't Instal/Prisons, Jails, etc							2
5		Gov't Installation/Dept of Sanitation		1					1
5		Gov't Installations/Fire Dept		2					4
5		Gov't Installations/Police Dept		1					2
5		Library					1		1
5		Museum						2	2
5		Post Office		1		1			3
								5 Total	22
6	Schools & Hospitals	Asylums and Homes/Misc					1		2
6		City University			1				1
6		Community Center							2
6		Education Structures/Misc					1		2
6		Hosp, Sanitariums, Mental Inst.							1
6		Hospitals & Hlth/Staff Facilities							1
6		Other Colleges and Universities		4					7
6		Parachial Schools, Yeshivas				1			4
6		Public Elementary Jr & Sr HS	1		1	1			8
6		Recreation Facilities/Misc							1
								6 Total	29
7	Hotels	Hotel/Lux Type Built After 1960					1		4
7		Hotels/Apartments Hotels							1
7		Hotels/Dormitories							1
7		Hotels/Miscellaneous	1				1		5
7		Hotels/Private Club, Lux Type		1			1		4
								7 Total	15
8	Offices	Office 10 Fls & Over/Main Av		9			22	14	111
8		Office Big/10 Fls & Over/Side St							11

8		Office Big/Fireproof to 9 Stores		2			2		5		36
8		Office Bldg/Semi-Fireproof		8	1				1		17
8		Office Bldg/Tower Type	3	1	2		17		15		57
8		Office Bldgs/Misc.		16	6	1	2	4	8		91
8		Professioal Office Building		2		1		1			7
									8 Total		330
9	Unknown	(blank)	1	3					2		16
9		Misc, Incl, Riding, Acadm & Stable									2
9		Miscellaneous		4	10			1			16
9		Other	2	3	1		2				15
									9 Total		49
10	Utility	Dept of Gas, Water, & Elec						1			1
10		Dept of Marine & Aviation	1								2
10		Dept of Public Works						1			1
10		Electric Utilities		1		1					2
10		Telephone Utilities		2					1		4
10		Transportation Facilities/Misc.						2			3
10		Transportation, Public Ownersh		1							4
									10 Total		17
x	Outdoor Space	Bridges, Tunnels, Highways		1							3
x		Cemeteries									2
x		Licensed Parking Lot		1							6
x		Parks		1	1			2			9
x		Playgrounds						3			5
x		Stadium, Race Track, Baseball Fl						3			3
x		Vacant Land	3	13	9	1	1	7	3		62
x		Vacant Land/Fire Dept			1						1
x		Vacant Land/Misc.		1				1	1		12
x		Vacant Land/School Site or Yar				1					1
									x Total		104
									Grand Total		2233

Figure 2. Simulation of WTC plume on the morning of the attack. National Oceanic and Atmospheric Administration meteorological stations are indicated as: Newark (EWR), Teterboro (TEB), LaGuardia Airport (LGA), Central Park (NYC) and John F. Kennedy Airport (JFK). Numbers in red are the hourly average concentration of particulate matter ≤2.5 μm in size in $\mu g/m^3$. Plume direction is towards the south-southeast and dilution of the plume varies from less than 500 to approximately 1,000,000.